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DTED
(DIGITAL TERRAIN ELEVATION DATA)
STUDY

by

Captain Donald B. Johnson

JUNE 1992

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PREFACE

This report documents work done on Project 81415-25/26/31 by USAFETAC's Special Projects Section (ECS). It satisfies one of the recommendations of an in-house study to determine the feasibility of incorporating Defense Mapping Agency (DMA) Digital Terrain Elevation Data (DTED) into the Air Force Global Weather Central (AFGWC) Atmospheric Slant Path Analysis Model (ASPAM).

This project was undertaken to determine the feasibility of (and best method for) incorporating the DMA database into the model, as well as to investigate other USAFETAC uses for the data. This report compares and contrasts the AFGWC eighth-mesh terrain data with the new DMA data to illustrate the differences between data densities.

After discussing the various computer-accessible terrain databases now available to USAFETAC analysts, the report introduces the DMA DTED database, which has a resolution of 3 arc seconds. Since it is of such high resolution that it produces much more data than most of USAFETAC analysts need, we developed a filter that reduces the data to a manageable size while maintaining the required accuracy.

The author would like to thank Mr Mark Surmeier, Chief of the Environmental Applications Special Projects Section, for his ideas and his help in completing this project. Thanks also to Mr. Charles Coffin of USAFETAC's Environmental Simulation Section (DNY) for valuable statistical information. For their technical assistance, we thank Mr Charles Sattler and TSgt Ronald Coleman of the Applications Programming Section (ADL).

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1. INTRODUCTION

1.1 History. This project began as an outgrowth of a USAFETAC point analysis (PA) study completed in August 1990. One of the study's main conclusions was that the primary source of PA quality degradation was caused by the coarse grid spacing of the AFGWC eighth-mesh terrain data. This finding confirmed a long-held belief by members of the USAFETAC PA team. The PA model had previously assumed that interpolated terrain represented real topography. In mountainous areas, this assumption caused errors resulting from bilinear interpolation of terrain heights using the four surrounding 8th-mesh grid points. These errors were on the order of thousands of meters. To correct the problem, the PA study report recommended that USAFETAC acquire the Defense Mapping Agency (DMA) high density Digital Terrain Elevation Data (DTED) as quickly as possible.

1.2 Purpose. This project was undertaken to determine the feasibility of (and best method for) incorporating DMA's 3 arc second terrain height data into the PA model, to correct the elevation precision, as well as to investigate other USAFETAC uses for the data. Calculations suggested that existing elevation databases, as well as those under development, contributed to unacceptable errors in USAFETAC products. The PA study proposed that a 1 percent error be considered reasonable and acceptable. This proposal has so far gone unchallenged; this report takes into consideration the results of its acceptance and adoption. This report also compares and contrasts the AFGWC eighth-mesh terrain data with the new DMA data to illustrate the differences between data densities.

1.3 Impetus. Terrain height errors have significant effects on studies sensitive to atmospheric quantity and structure, such as those that concern density and transmissivity. PA analysts and users had previously tried to avoid such errors by using Operational Navigation Charts (ONCs)--USAFETAC's primary terrain data source. This entailed extensive manual effort. Up to now, the cost of this labor was absorbable; projects were smaller and turn-around times were generous. But with expanding areas of interest, tighter suspenses, and reductions in force, these labor-intensive methods had to eliminated or reduced as much as possible.

1.4 Requirements. Our primary concern was determining how fine the coarsest terrain grid resolution should be to allow consistently accurate PA production. Since the eighth-mesh resolution is too coarse, how fine should the resolution of the terrain height database be? The answer depends on how much error is acceptable in the final PA product. The total error can be divided into two parts: the part that is terrain-induced, and the part that is induced by less correctable atmospheric variables. For example, if a 1 percent error in density due to terrain inaccuracies is acceptable, then, according to the PA study, heights should be specified to within 300 feet. Correct elevations are essential for proper functioning of the automated PA models; to provide the required degree of accuracy, DTED acquisition was an immediate necessity.

2. GRID SYSTEMS

2.1 Eighth-Mesh Grid. The eighth-mesh grid is based on a secant polar-stereographic projection, which is true at a latitude of 60 degrees. Each hemisphere is divided into 64 (8x8 array) equally-sized areas, or "boxes," as shown in Figures 2-1 and 2-2. Each box is divided into 64 by 64 gridpoints; each box, therefore, contains 4,096 points and each hemisphere contains 262,144 points. Only 195,912 points in each hemisphere, however, are "on-globe". Grid spacing is variable due to distortion in the polar-stereographic projection. Data points are spaced between 13.78 nm at the Equator and 27.56 nm at the poles, with an average resolution of 25x25 nm. Each computer word (4 bytes) represents a single gridpoint; therefore, the size of the database amounts to four times 524,288 bytes, or about 2.1 megabytes (MB). There are about 12 eighth-mesh points per square degree. In some cases over flat terrain, this is sufficient. But for many applications, especially over rough terrain, it's not nearly good enough. USAFETAC has two eighth-mesh gridded terrain height databases with worldwide coverage: one is from AFGWC; the other, from Phillips Laboratories (PL).

2.1.1 AFGWC Geographical Terrain Height Database. The AFGWC terrain file was originally created for the 3DNEPH model, which was developed in the early 70's with terrain height data from the Scripps Institute of Oceanography. This data file contained terrain elevation (above and below sea level) averaged over a degree square. When the data was made to fit the eighth-mesh grid, it already contained an element of error. To make the file more representative, some elevations were improved manually with ONC data. Terrain heights were then smoothed so that there would be more of a progression from low to high elevations. Figure 2-3 shows what the AFGWC eighth-mesh terrain height data would "see" over a mountainous area. The figure shows an area of North central Iran bounded on the north by the Caspian Sea. The mountains run from northwest to southeast across the center of the chart. (Note: Contour interval in Figures 2-3 through 2-6 is 500 meters. The maps are necessarily reproduced here in monochrome, which makes contour legends difficult to interpret. They are included only to give readers an idea of the *differences* in the databases. For those who wish to interpret actual elevations, color copies are available. Call USAFETAC/ECS, DSN 576-3543.)

2.1.2 Phillips Laboratories Terrain Height Database. This database (produced by PL's Geophysics Directorate) was interpolated to the grid from the Navy's 10 arc minute terrain database. Figure 2-4 shows the same area as Figure 2-3, but this time with the PL data. Although the highest elevations here are higher (and the lowest elevations lower) than those in Fig 2-3, there is little additional detail.

2.2 Sixty-Fourth Mesh Grid. The 64th-mesh grid is based on the same projection as its eighth-mesh counterpart, except that the 8x8 boxes are divided into 512x512 gridpoints. Each of the 64 boxes contains 262,144 points. Each 64th-mesh hemisphere therefore contains 16,777,216 points. There would be an estimated 12,538,368 points in each hemisphere that would be "on-globe."

Data points are spaced between 1.72 nm (at the Equator) and 3.44 nm (at the poles). Since each computer word (4 bytes) represents a single gridpoint, the size of the entire database would amount to 4 times 33,554,432 bytes, or about 134.22 MB. There are 774 64th-mesh points per square degree. This should provide sufficient data density for about half the world's terrain.

AFGWC expects delivery of the 64th-mesh gridded terrain height database from PL in CY92. It will specifiy a much higher percentage of the Earth's landmass than its eighth-mesh counterpart. However, almost half the Earth's landmass would still require a finer resolution. In mountainous terrain, there can still be over 50% of all height errors in excess of 300 feet at 64th-Mesh. Figure 2-5 shows the same area as the first two charts, but with a resolution approximating that of the 64th-mesh grid.

2.3 Digital Terrain Elevation Data "Grid." The DTED "grid," if it can be called that, has data points spaced 3 arc seconds apart in the north-south axis and 3-18 arc seconds in the east-west axis, depending on latitude. At the Equator, 3 arc seconds is about 304 feet (1/20 nm). It does not have global (or even hemispheric) coverage like the eighth- and 64th-mesh grids. Coverage is almost exclusively over land. As shown in Table 1, this "grid" is more a combination of latitudinal grid bands.

TABLE 1. Variation of Grid Spacing by Latitude Band.

Latitude Band	Grid Spacing Lat Lon	# of Points N/S E/W	Points/Cell	Bytes/Cell	Approx # of Cells *
0°-50° N/S	3 x 3	1201 x 1201	1,442,401	2,884,802	11,891
50°-70° N/S	3 x 6	1201 x 601	721,801	1,443,602	5,393
70°-75° N/S	3 x 9	1201 x 401	481,601	963,202	910
75°-80° N/S	3 x 12	1201 x 301	361,501	723,002	707
80°-90° N/S	3 x 18	1201 x 201	241,201	482,402	349

**Worldwide estimate (Antarctica and water cells excluded)*

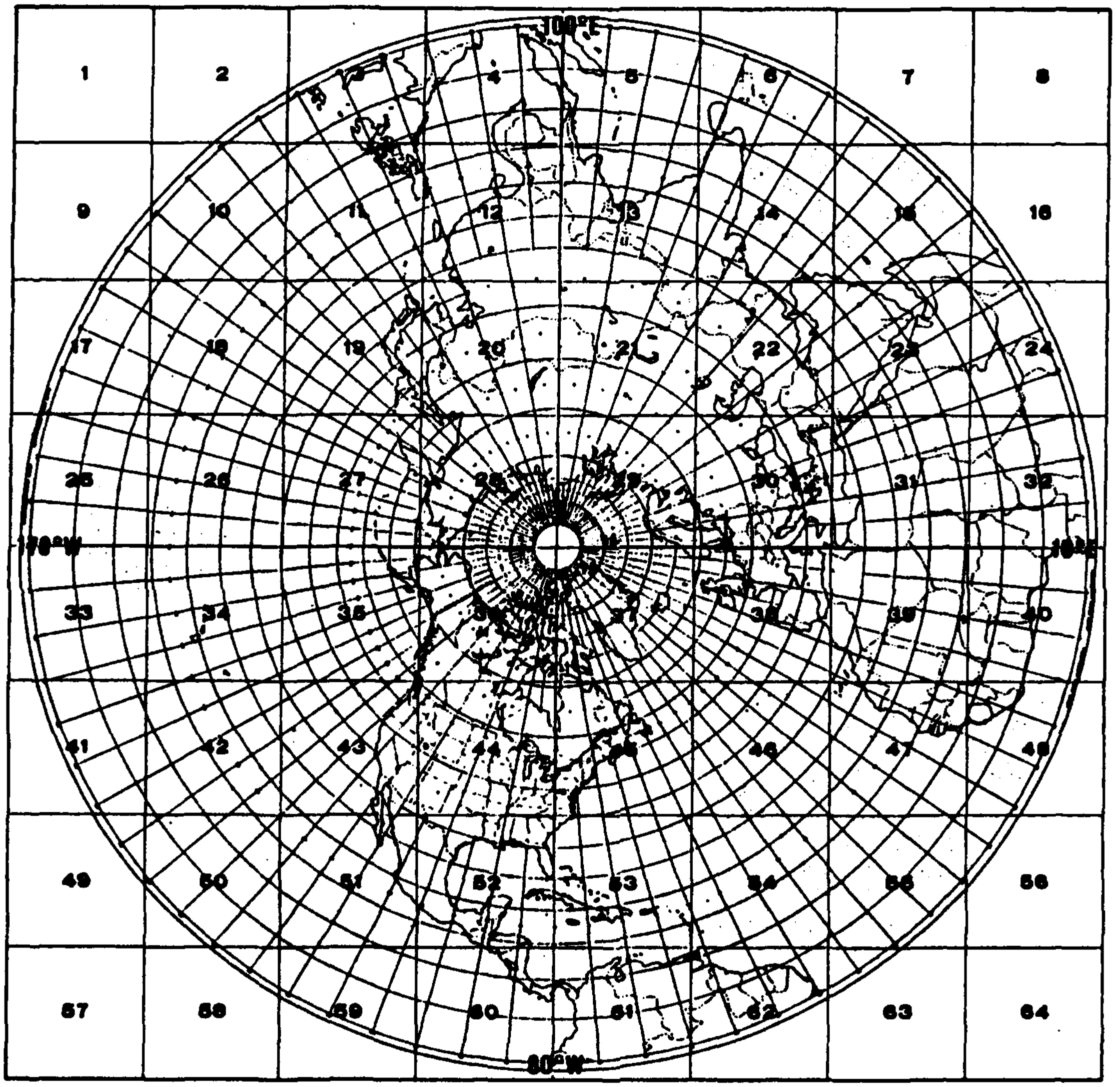

Figure 2-1 Eighth-mesh projection--Northern Hemisphere.

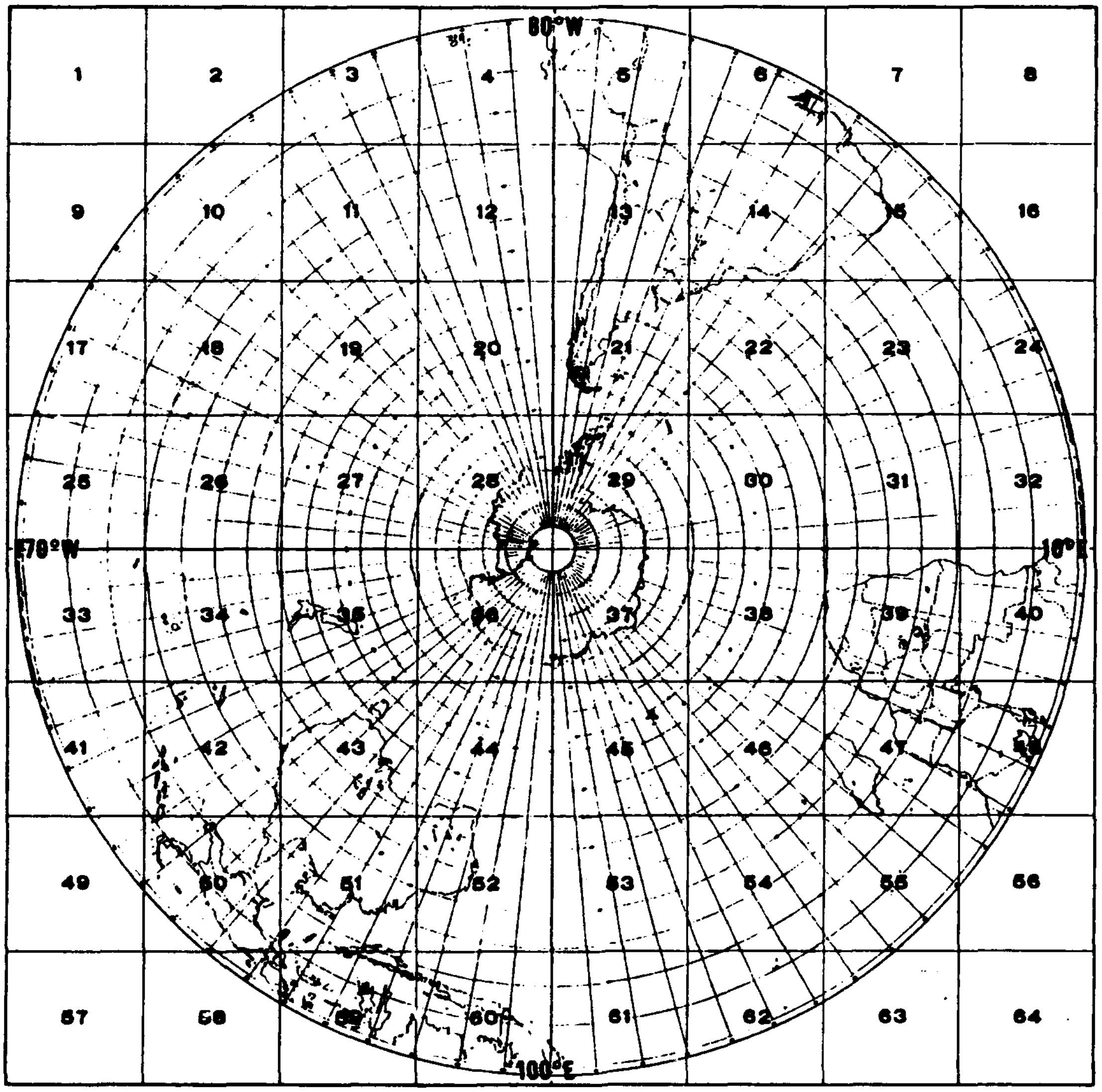

Figure 2-2 Eighth-mesh projection--Southern Hemisphere.

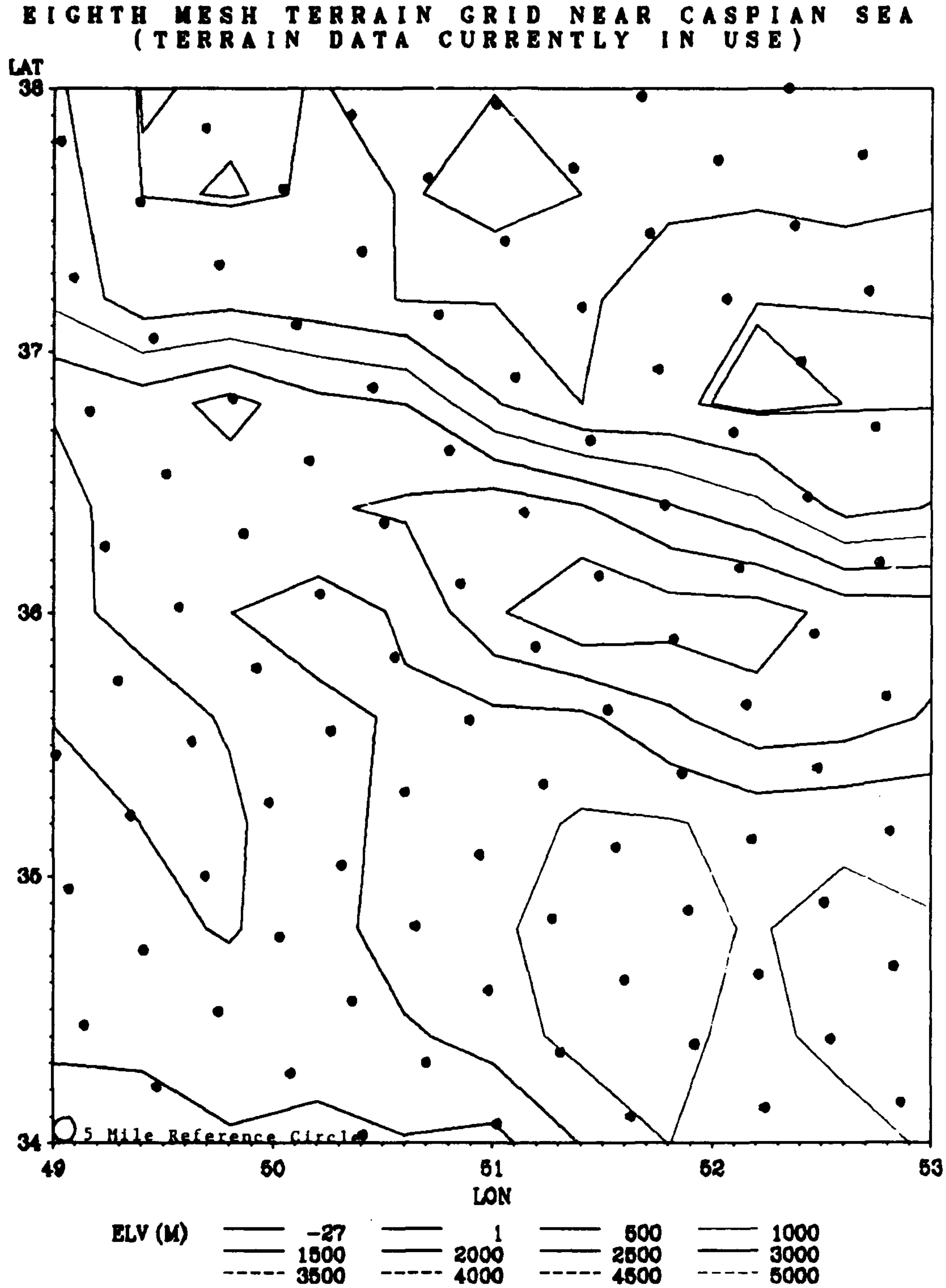

Figure 2-3 Eighth-mesh contour--AFGWC terrain data. Area shown is near Caspian Sea. The black dots represent the eighth-mesh grid points in this area.

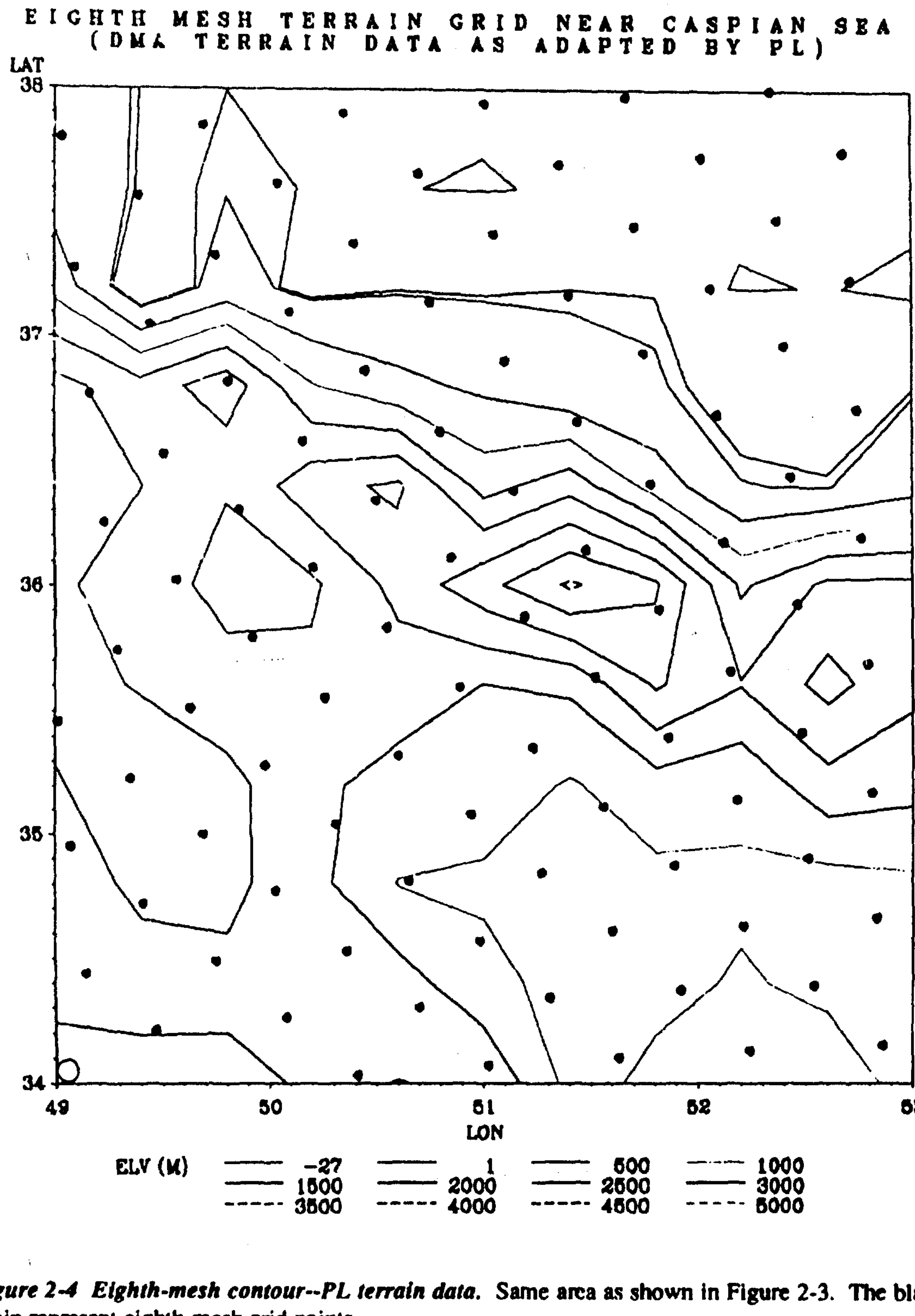

Figure 2-4 Eighth-mesh contour--PL terrain data. Same area as shown in Figure 2-3. The black dots again represent eighth-mesh grid points.

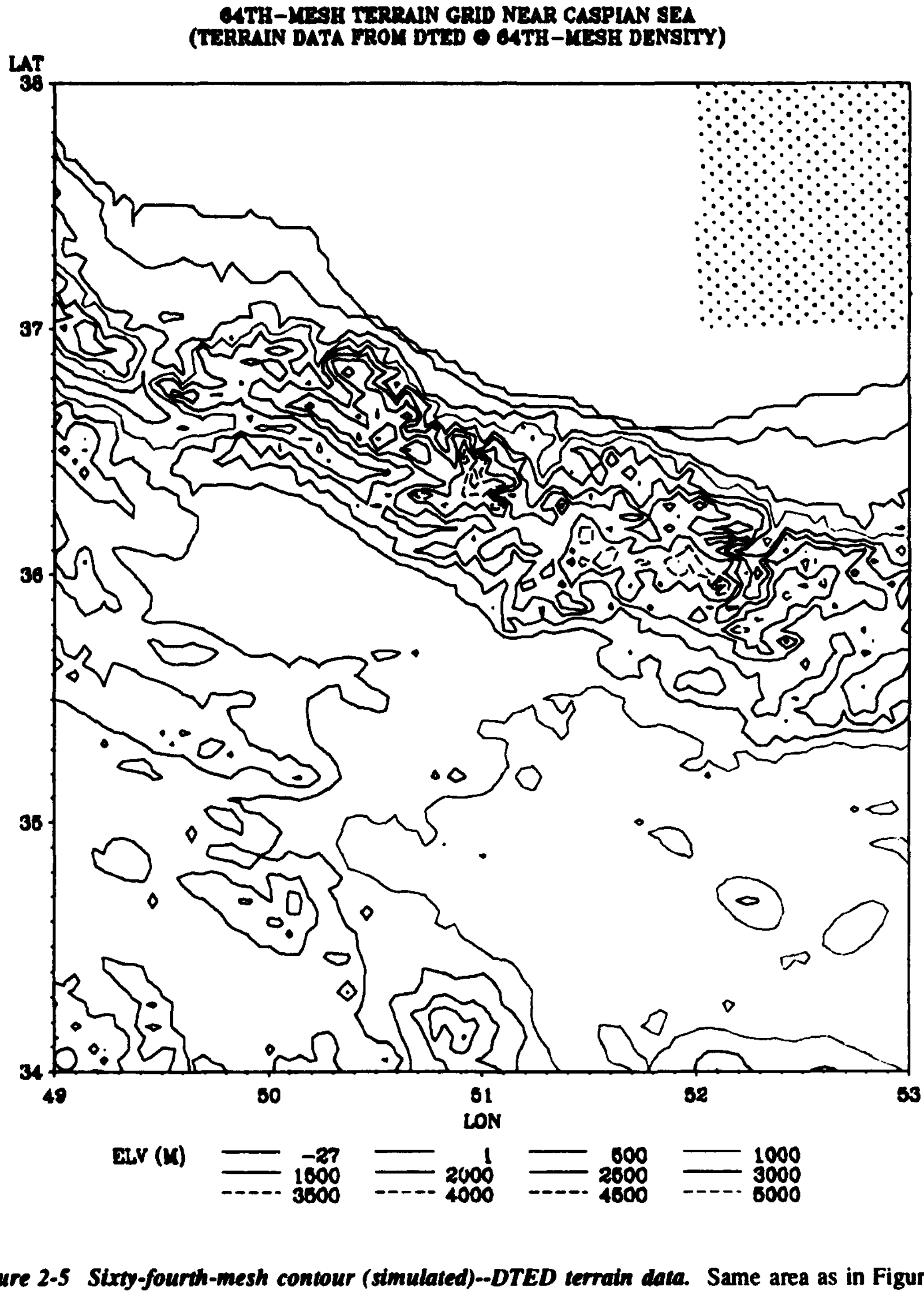

Figure 2-5 Sixty-fourth-mesh contour (simulated)--DTED terrain data. Same area as in Figures 2-3 and 2-4. The dot pattern in the upper right-hand (northeast) corner represents the 64-mesh grid points over the *entire* chart area; it is shown here only in the corner so as not to interfere with contour lines.

2.3.1 DTED Data Analysis. The Defense Mapping Agency (DMA) provides DTED as a stand-alone product designed to contain terrain heights in digital form with known geographic control. A DTED data file is a 1- by 1-degree area called a "cell." Cell boundaries are defined by the integer latitudes and longitudes, and are referenced by the latitude and longitude of the Southwest corner of the cell. Terrain elevations are expressed in whole meters above MSL. Data accuracy is officially reported to be 130 meters horizontal and ±30 meters vertical at the 90% confidence level, but DMA analysts have stated that the accuracy is usually much better than stated.

2.3.2 DTED Data Volume. Unlike the 8th- and 64th-mesh grids, DTED does not cover the whole world, but just the land areas. DMA has not digitized all the land areas, but adds more every year. There are about 70,000 DTED points covering the same area as four eighth-mesh points, and about 3,600 DTED points covering the same area as four 64th-mesh points. Figure 2-6 shows the same area as Figures 2-3 through 2-5, but this time using every 10th DTED point (1% of total). By multiplying the number of cells in each latitude band by the number of bytes required to store such a cell (from Table 2-1), we get just under 44 gigabytes (GB). (If DTED were a global database, it would require over 134 GB!) It was impossible to free up that much USAFETAC DASD, and it was questionable that our analysts would ever need that much data since the degree of accuracy to be gained would, for most cells, be inconsequential. Hardware costs dictated an extensive cost vs benefit analysis to determine just how much precision was actually required.

2.3.3 Fixed vs Variable Grids. By extracting every second DTED point and interpolating the skipped points as needed, the worldwide volume of data would be reduced from 44 to 11 GB without much loss in accuracy. Now the question was how much DASD was needed for DTED? If we only had 1 GB to use, then we would need to store 1/44th of the data, or about every sixth or seventh point. We could have stored it that way and, over flat areas of the world, we could get away with storing even less. But in more rugged areas, we would need to store more. With that in mind, we looked at the problem in a different way. Since the terrain in each cell is unique, why not choose a data density for each cell so that the interpolated differences from the actual elevation satisfy some specific criteria?

2.3.4 Data Filter. Since the largest any DTED cell can be is 1,201 by 1,201 points, the simplest data filtering algorithm is one that extracts all points that are multiples of one of the factors of 1,200, of which there are 30. The points skipped over would be interpolated using a bilinear interpolation formula and the differences from the actual elevation would be tabulated. If the number of differences greater than the interpolation criteria exceeds a predetermined value, then the process is repeated with a finer resolution. Appendix A lists each of the factors with the amount of data reduction of each. For example, extracting every 60th point in a cell between 50° N and 50° S would result in a 21x21 array of points spaced 3 arc minutes apart (about 3 nm). The I,J coordinates of these points would be from the set {1, 61, 121, 181,...,1141, 1201}. Each cell would reduce to one of the 30 factors.

2.3.5 Interpolation Criteria. How fine the resolution should be depends on the type of terrain at the point of interest and on the accuracy criteria of the model. The PA Study determined that an elevation difference of less than 300 feet is acceptable, but how many differences greater than 300 feet should be allowed in any one cell? The ideal would be *no* differences greater than 300 feet. But what effect would such a restriction have on mass storage? Would it have to be liberalized? To answer these questions and get a mass storage estimate on the reduced density cells, we had to develop the filter, process a statistically significant number of cells to get an approximate distribution of the cells by reduction factor, and finally, extrapolate the results to the rest of the world.

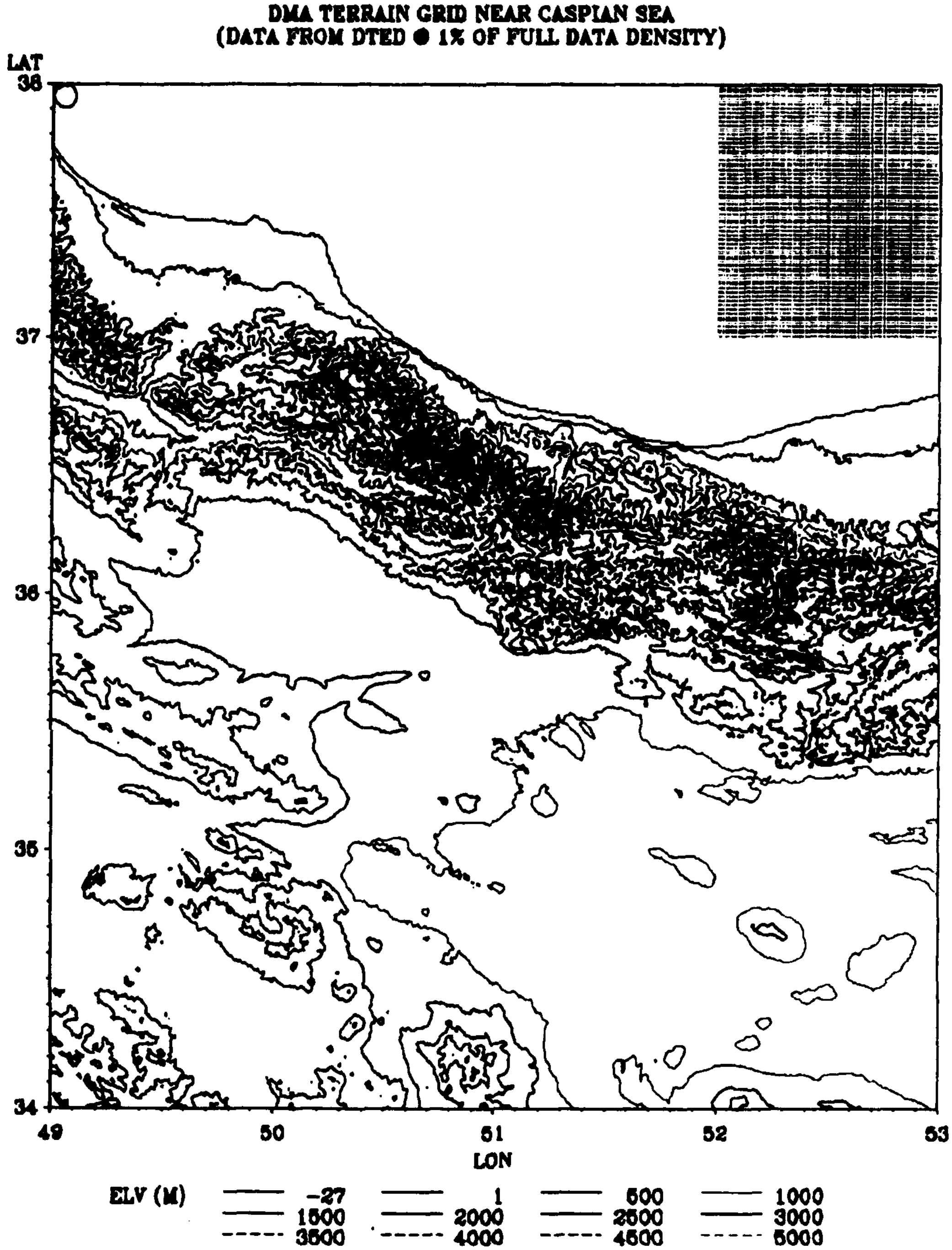

Figure 2-6 DTED contour (1%)--DTED terrain data. Same area as Figures 2-3 through 2-5. The dot pattern in the upper right-hand (northeast) corner represents the 1% DTED grid-point spacing over the ***entire*** chart; it is shown here only in the corner so as not to obscure the contours.

2.3.6 Storage of DTED Cells. The storage of reduced DTED cells on disk was meant to mimic their storage on tape. Because the number of points in the longitudinal direction varies with latitude, the data (on tape) is stored sideways to ensure a constant record length. Therefore, the number of records per cell is the only thing that varies. The same logic was used to store the reduced cells. This was done for two reasons: First, to save space. The data is stored in binary format, which uses less DASD than other formats. The second reason was to ease the quality control effort; i.e., it's easier to compare cells in the same format. All cells of a like reduction factor were stored together.

2.3.7 Naming Conventions. There are 30 PDSs with the R FACTOR as the name of the TYPE field in the format ETACXRF.DTED.Rxxxx, where xxxx is the four-digit reduction factor. Since member names must begin with a letter, the DTED cell is named N/SxxE/Wyyy. N is Northern Hemisphere; S, Southern Hemisphere. xx is the two-digit latitude. E is Eastern Hemisphere; W, Western. yyy is the three-digit longitude. Therefore, each cell has a unique member name.

3. METHODOLOGY

3.1 Requirements. Since the DMA data is on tape, the filter program would have to read the DTED cells from tape, test each resolution of data density (in ascending order of density) and, when the desired level of accuracy is met, save the reduced data in a format usable by others. Users can request a single point or an area of points to meet their needs. It would also be necessary to accomplish this with as little CPU time as possible.

3.2 System Design.

3.2.1 DTED Data Flow. Assuming that we were going to have reduced cells stored on-line, we had to be able to read the cells from tape, reduce them, store them, and read them to re-interpolate the missing data. The process was divided into two parts; a filter program, and a reinterpolation progam--see Figure 3-1.

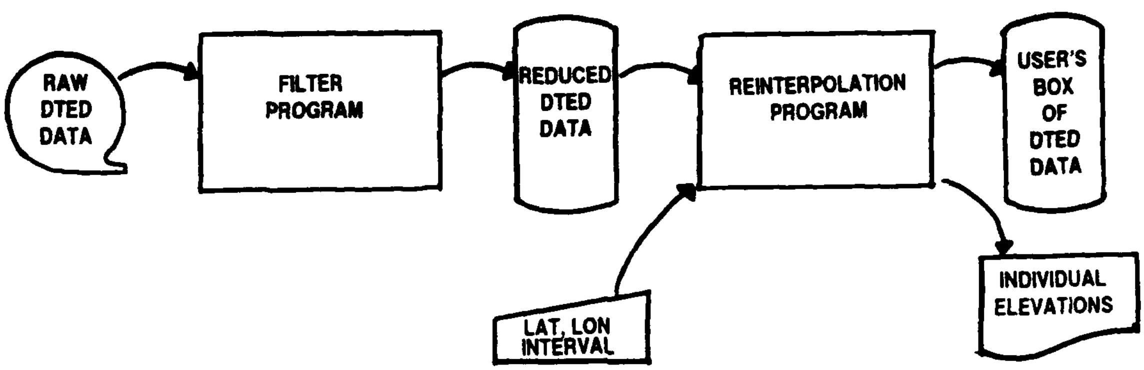

Figure 3-1. DTED Data Flow Diagram.

3.2.1.1 Filter Program. The program reads the raw data from tape, then finds the optimum reduction (R) factor for each cell. When the criteria are met, it saves the reduced data in the same format as it was read. The first tape required 4.4 CPU hours to process 30 cells. This time was easily divided into the processes on each cell done only once (e.g., reading from tape, writing to disk) and the processes on each cell done one or more times (e.g., each iteration of the searching algorithm). For example, a cell that evaluated to R=60 would be processed once by the reading/writing process, but 12 times by the rest of the program.

3.2.1.2 The Searching Algorithm. This algorithm determines the coarsest data density that meets the interpolation criteria. This portion of the filter program was by far the most expensive in terms of CPU use; before large-scale data reduction could begin, the algorithm had to be improved to reduce CPU use as much as possible.

The initial form of the algorithm was a linear search. Each reduction factor was searched, from the coarsest (R=1200) to the finest (R=1) until the criteria were met. The only advantage to this method was the guarantee that the coarsest R factor would be chosen. It required 12,385 iterations of the searching algorithm to reduce a sample of 983 cells.

The next form was a binary search. R factor 40 was selected first; the algorithm would then "jump" to a higher or lower R factor depending on whether or not the criteria was met. This had the advantage of reducing the number of iterations of

the searching algorithm to five per cell. The guarantee of finding the coarsest R factor that met the criteria was no longer valid, but it only took 4,903 iterations of the searching algorithm to reduce the same 983 cells, a 60% reduction.

We ultimately decided that a hybrid searching algorithm might save even more iterations due to the distribution of cells and factors.-see Figure 3-2. The range of elevation values within a cell might provide a clue as to what the R factor might be--see Figure 3-3. The larger the range, the finer that data had to be. We applied the linear search to the cells with the smallest range, and a binary search to the rest. Next, we had to determine where to draw the line. Since the elevation range for the coarsest four R factors were all less than 1,000 meters, we decided to test the range data at 50-meter intervals. There were 285 cells in the four coarsest R factors and 698 cells in the rest.

We counted how many of the 285 cells among the coarsest four were less than the threshold. These cells would be searched linearly and would only require one-four iterations; the rest would require five iterations apiece. we called these "crossover" cells because they "crossed over" the threshold.

We then counted how many of the 698 remaining cells were greater than the threshold; these also required five iterations. The rest of these cells had a range less than the theshold and would require 5-30 iterations. These were also crossover cells. By adding the columns of crossover cells, we could then determine which threshold had the fewest crossover cells and therefore the number of iterations required for that threshold. A threshold of 450 meters had the fewest crossover cells and required only 4,065 iterations--a 17% reduction, and a 68% reduction overall--see Table 2.

TABLE 2. Threshold Analysis of Elevation Range.

	NUMBER OF CELLS R Factors 300 - 1200		NUMBER OF CELLS R Factors 2 - 240		
Threshold (T)	Range < T	Range>=T	Range < T	Range>=T	Crossover Cells
50	47	238	0	698	238
100	75	210	0	698	210
150	104	181	0	698	181
200	140	145	0	698	145
250	170	115	4	694	119
300	199	86	6	692	92
350	234	51	10	688	61
400	250	35	23	675	58
450	263	22	33	665	55
500	269	16	48	650	64
550	272	13	55	643	68
600	277	8	72	626	80
650	281	4	85	613	89
700	282	3	99	599	102
750	282	3	111	587	114
800	284	1	123	575	124
850	284	1	139	559	140
900	284	1	145	553	146
950	285	0	159	539	159
1,000	285	0	168	530	168

NOTE: 983 Total Cells @ LINEAR Require 12,385 Iterations
983 Total Cells @ BINARY Require 4,903 Iterations
983 Total Cells @ T= 450 Require 4,065 Iterations

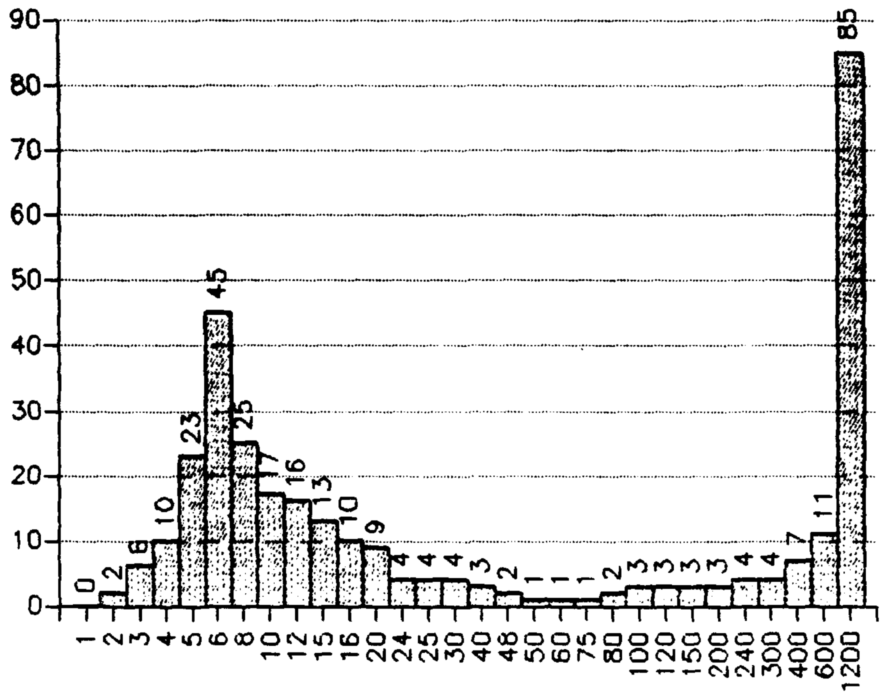

Figure 3-2 Distribution of DTED cells--sample data.

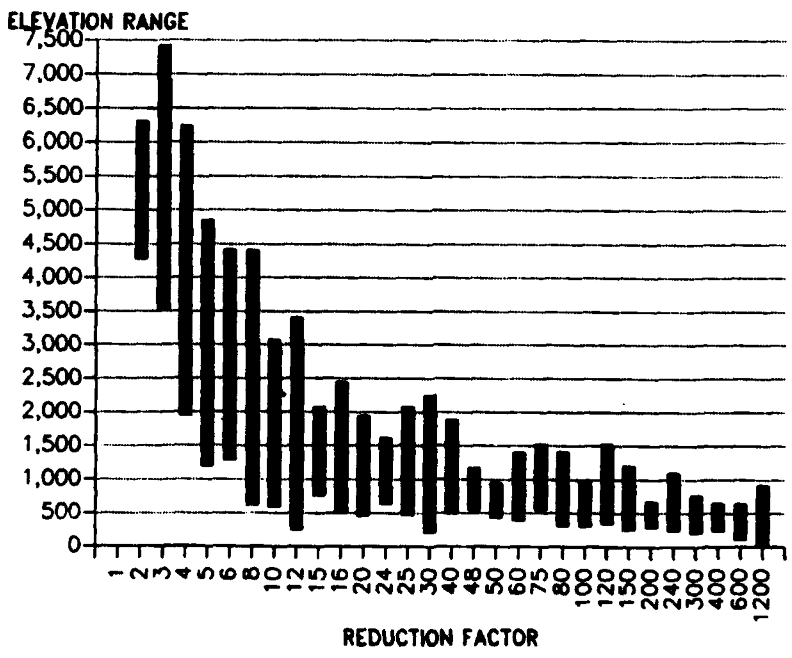

Figure 3-3 Elevation range by reduction factor.

3.2.1.3 Sizing. The initial requirement was that 100% of interpolated differences had to be less than 300 feet. Once we had reduced our initial batch of cells, we extrapolated the results to the rest of the world to estimate mass storage requirements for this criterion. Storing the full density of data required almost 44 GB. The 100% criterion would reduce the amount to about 36 GB, still much more than we could afford. Therefore, we proposed a realistic second condition that 99% of differences had to be less than 300 feet. That brought the total down drastically to just under 1 GB. Figure 3-4 compares the two criteria with storage of full data density.

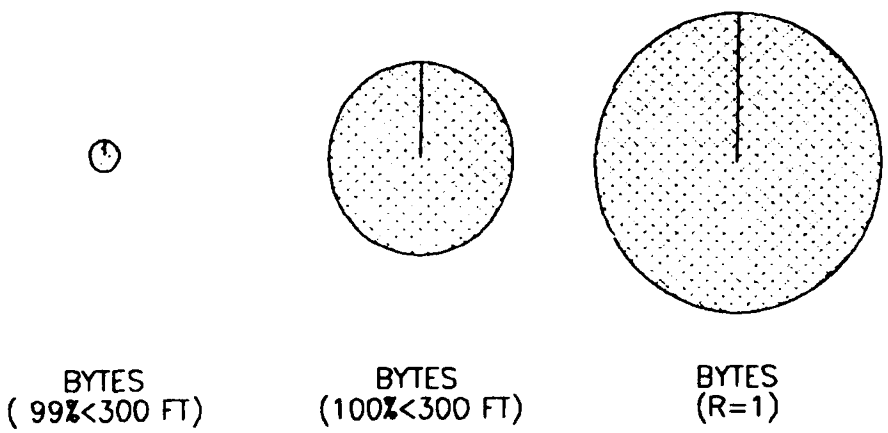

Figure 3-4 Data volume by interpolation criteria.

3.2.1.4 Stability of Criteria. The "99% of differences less than 300 feet" criterion makes the program very sensitive to even the most subtle terrain, but not nearly as sensitive as a criterion of 100% would give. One percent of a cell is a very small area. If there were a single mountain in 1% of the area of an otherwise completely flat cell, that cell could analyze to about R=100. But if that 1% area occurred at one of the corners, the cell might go all the way down to R=20 or less. This sort of thing actually happens in about 5% of all cells, especially near coastlines. The mountain does not even have to be very tall. For example, there is a cell in India at 25° N, 76° E, where there are no mountains to speak of--just a scattering of small hills no more than 300 meters above the surrounding terrain. The elevation range for the whole cell is only 364 meters. This cell, however, analyzed to R=30. At R=1,200, the percent of differences less than 300 feet was more than 94%. Had the criteria been 98% <300 feet, it would have been an R=400 cell. Most of the time, however, every degree of refinement in resolution increases the number of differences <300 feet between 10 and 35%. Another oddity is that about 2% of cells that meet the 99% criterion at a certain resolution fail to meet the criterion at the next finer resolution. This is due almost entirely to the chance placement of hills and valleys within the cell in relation to the data spacing.

3.3 Data Extraction Program. Once the reduced data was on-line, we had to write an extraction program that would give analysts access to the data. The naming conventions we used to store the data made it easy to find the cells when needed. The area required by an analyst could span many cells, each with a different R-factor. Once the program found the required data, it produced an output dataset at the interval requested by the analyst. Finally, we automated the entire process to make access as user-friendly as possible.

4. EPILOGUE

4.1. Reduced DTED Size. With 11,233 reduced cells on-line (of an estimated maximum of 19,250) DTED uses about 270 MB, slightly over half what was originally expected. Apparently, the original assumption (that the initial survey of reduced cells provided a significant over-estimate of the size required) was not truly representative of a random distribution of terrain cells. Considering the terrain, however, it was a good guess. The net effect of this project was to reduce a 44-GB database to an estimated maximum size of only 400 *MB*, a better than 99% reduction that resulted in savings of $2 million.

4.2. Reduced Number of Reduction Factors. When the time came to contour the data, cells with a reduction factor at 100 or coarser did not correspond well visually with actual terrain, especially near coastlines, despite the fact the data was within 300 feet of normal. The data points at R=100 were so coarse over flat terrain that graphics products were not useful. Because of this, we changed the number of reduction factors from 30 to 21, with the five coarsest (1,200, 600, 400, 300, 200) used only for storing water cells for each latitude zone, leaving 16 factors for storing terrain. The coarsest resolution was set to R= 50. Factors 24 and 48 also were deleted because of the low number of cells reducing to those numbers. This reduced the maximum number of iterations per cell from five to four. It required only an extra 1% DASD.

4.3. DTED Integration. Integrating DTED into ASPAM involved modifying the data extraction program to return a single point of data (as opposed to an area of points) and to convert the program to a subroutine. Because DTED had incomplete worldwide coverage, we had to add exception coding to the ASPAM code to to handle cases in which DTED was not available. We also had to revise the ASPAM input and output templates because they did not use arc seconds. The only other change was to increase the number of saved significant digits to allow the greater horizontal accuracy DTED provides.

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APPENDIX

NUMBER OF POINTS PER CELL (ALL LATITUDE BANDS) BY REDUCTION FACTOR

	LATITUDE ZONES				
REDUCTION FACTOR	**00-50 N/S (1201x1201)**	**50-70 N/S (1201x601)**	**70-75 N/S (1201x401)**	**75-80 N/S (1201x301)**	**80-90 N/S (1201x201)**
1	1,442,401	721,801	481,601	361,501	241,401
2	361,201	180,901	120,801	90,751	60,701
3	160,801	80,601		40,501	
4	90,601	45,451	30,401	22,876	15,351
5	58,081	29,161	19,521	14,701	9,881
6	40,401	20,301		10,251	
8	22,801	11,476	7,701		3,926
10	14,641	7,381	4,961	3,751	2,541
12	10,201	5,151		2,626	
15	6,561	3,321		1,701	
16	5,776		1,976		
20	3,721	1,891	1,281	976	671
24	2,601	1,326			
25	2,401	1,225	833	637	441
30	1,681	861		451	
40	961	496	341		186
48	676				
50	625	325	225	175	125
60	441	231		126	
75	289	153		85	
80	256		96		
100	169	91	65	52	39
120	121	66			
150	81	45		27	
200	49	28	21		14
240	36				
300	25	15		10	
400	16		8		
600	9	6			
1200	4				

GLOSSARY OF TERMS AND ACRINABS

Acrinab	Acronym, inititialism, or abbreviation
AFGL	Air Force Geophysics Lab (Now Phillips Laboratories)
ASPAM	Atmospheric Slant Path Analysis Model (formerly IPAM).
Cell	A one-degree by one-degree section on the surface of the earth that includes, but does not cross, whole-degree latitudes or longitudes.
CPU	Central processing unit--that part of the computer that does the actual computing.
DMA	Defense Mapping Agency
DTED	Digital Terrain Elevation Data
Data Filter	A process by which the volume of data in a cell is reduced to a minimum while still meeting the interpolation criteria.
GB	Gigabyte (1,000 megabytes)
Interpolation Criteria	The accuracy requirements of a cell, based on the PA study.
IPAM	Inproved Point Analysis Model (now ASPAM).
MB	Megabyte (1 million bytes)
MSL	Mean sea level
ONC	Operational Navigation Chart
PA	Point analysis (atmospheric profile).
PL	Phillips Laboratory (formerly AFGL)
Reduction Factor (R)	A factor of the number of longitudinal points less one in a cell.
R-Factor	Reduction factor
RTNEPH	Real-Time Nephanalysis Model
3DNEPH	Three-dimensional Nephanalysis Model

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